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BRIEF

EXPLANATION OF GEODETIC TARGET ERROR FOR THE ICBM
IN RELATING LAUNCH AND TARGET POINTS
ON DIFFERENT CONTINENTS

Introduction

US ICBM tests have demonstrated a capability of impacting nosecones within less than 2 n. miles of the designated target. This achievement not only exceeded expectations of American engineering, but in so doing it must be noted that a significant factor contributing to this accuracy -- and its calibration -- was the accurate geodetic positional relationship of the launch and target points to an error of about +500 feet. Unfortunately such geodetic accuracies are currently attainable by the US only for European USSR. This paper explains in brief, non-technical terms the nature of the geodetic problem and efforts to improve current inadequate geodetic accuracies.

A. The problem of intercontinental geodetic inaccuracies arises from the diversity of geodetic systems and difficulties of interconnections across the oceans

1. Continental systems of geodetic control end abruptly at coast lines.
2. Gaps in control over ocean areas create uncertainty in positioning of the continents.
3. The large geodetic nets of the world are based upon different datums.*
4. The US uses the North American Datum, adopted 1927; the USSR uses the Pulkovo 1942 Datum, adopted in 1946.

*See the Annex for explanation of the basic elements of the geodetic problem.
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5. Datum differences give rise to errors in computing distances and directions between widely separated launch and target points.

6. Ultimate target accuracies depend on availability of identifiable geodetic points to which targets must be related.

B. Geodetic errors develop because the earth is not a true sphere but an irregular figure flattened at the poles and having a bulge near the equator.

1. Size and shape of the earth -- estimates of semi-major axis and polar flattening have varied widely causing differing discrepancies in the fitting of an ellipsoid to the geoid (generalized undulating sea-level earth surface).

2. Orientation of ellipsoids -- ellipsoid axes do not coincide with earth's axis of rotation thus making positions of different geodetic systems not directly comparable for geodetic computations.

3. Errors due to deflections of the vertical -- result from angular differences between observations that are vertical to the geoid and computed as perpendicular to a displaced ellipsoid.

C. Insufficiency of Soviet geodetic data and large-scale maps causes a significant US disadvantage in accurate location of targets

1. Systematic geodetic data on USSR are unavailable east of Leningrad - Gorkiy - Novosibirsk. Prevents production of accurate maps or use of aerial photography for computing target locations.

2. Modern large-scale maps are lacking for vast areas east of Gorkiy and the Caspian.

3. Map error is determined by scale of available maps. Negligible if scales are 1:100,000 or larger but significant, particularly for locating Soviet ICBM sites, in areas covered at scales of 1:1,000,000 or smaller.

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4. Gravity anomalies have an effect on missiles during flight.

D. Comparative estimates of US-Soviet geodetic target error over a 5,500 n. mile range show a US disadvantage

*US Against USSR

**USSR Against US

1. Error due to uncertainties in size, shape of ellipsoid, and target uncertainty
US against USSR:
 - a. 1,000 feet or better applicable against pre-selected targets, European USSR.
 - b. 2 n. mile applicable against Soviet launch sites with locations still to be ascertained
2. Map error, varies with scale of available maps
200 to 2,000 feet 100 to 500 feet
3. Gravity error; lower value more probable
500 to 2,500 feet 500 to 2,000 feet
4. Estimated Over-All Geodetic Error
 - Average instance 0.3 to 0.6 n. mile
 - a. For 90 percent of European USSR targets Within 1,000 feet
 - b. For remainder of USSR
 - 50 percent certainty 2,000 feet to 1 n. mile
 - 90 percent certainty 4,000 feet to 2 n. mile

*Simplified rounding of representative estimates provided by Army and USAF sources

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Differences between US and USSR based on Soviet advantage of withholding maps and

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E. US programs to improve geodetic accuracies are particularly necessary for greatly improving future weapons systems. [Present geodetic requirements are +1,000 feet; current projections are +500 feet (1965), and +250 feet (1970)]

1. Planned or current scientific program to reduce geodetic error

a. Different national geodetic systems on different ellipsoids which have been connected since World War II into continental systems (European, Tokyo, North American) have been connected into a single system by the Army and the Air Force. Recently, these two have been reconciled into a single Defense World Geodetic System. This, however, represents only a first approximation. Additional programs are mandatory for refinement and verification.

b. IGY lunar photography program; results expected in 1 to 2 years.

c. HIRAN (high-precision Shoran) for intercontinental ties. Results reduced uncertainty of connections between Europe and North America to about 240 feet; uncertainty still exists because of weaknesses in Canadian geodetic positions established by Shoran methods.

d. World gravity survey; still under consideration for oceanic survey. Surface-ship and airborne instrumentation now being tested; will reduce cost and speed up completion of survey.

e. Earth satellite observations and orbit analysis; intercontinental ties with +100 accuracy expected by about 1965.

f. High-altitude rocket flashes for determining three-dimensional coordinates between continents giving positions free of deflection-of-the vertical errors; programs now in planning.

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g. Reconnaissance satellite photography may within 5 years yield most direct and accurate checks on intercontinental positions and (hopefully) provide geodetic positions in the USSR for which no data are now available.

2. Collection of Soviet large-scale maps and geodetic data are essential for identification and accurate positioning of targets, especially in the Urals and all of Siberia.

a. Soviet maps (1:100,000; 1:50,000; 1:25,000) and geodetic data have been sought unsuccessfully since end of World War II. Collection now made a top priority target to fulfill a First Category Priority National Intelligence Objective (para. f); coordinated clandestine effort being markedly increased; yield to date, 13 East German map sheets at 1:25,000; 102 additional sheets obtained through chance events (defections).

b. Efforts made at international scientific meetings to secure data; no success to date.

F. Comparison of US and USSR

1. Competence of US and USSR geodesists -- generally comparable; Soviets possibly superior in field of theoretical gravity and number of trained personnel.

2. USSR has vastly greater number of trained geodesists for future use in missile operations.

3. Soviets have geodetic targeting advantage over US, resulting from:

a. Soviet policy of withholding topographic maps from West. The all-purpose Soviet series at 1:100,000 are very tightly held;

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available large-scale maps are of pre-1940 date and limited in coverage, especially for Siberia.

b. Soviet withholding of all gravity and geodetic data.

Revision of Soviet geodetic system in 1946. Soviets have comparable US data. Available data are of the Pulkovo 1932 system. No Soviet data available on the new Pulkovo 1942 system. Soviet Union, however, has comparable US data.

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